BS EN 60871-4:2014

BSI Standards Publication

Shunt capacitors for AC power systems having a rated voltage above 1 000 V

Part 4: Internal fuses

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National foreword

This British Standard is the UK implementation of EN 60871-4:2014. It is identical to IEC 60871-4:2014. It supersedes BS EN 60871-4:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/33, Power capacitors.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Shunt capacitors for AC power systems having a rated voltage above 1 000 V - Part 4: Internal fuses (IEC 60871-4:2014)

Condensateurs shunt pour réseaux à courant alternatif de tension assignée supérieure à 1 000 V - Partie 4: Fusibles internes
(CEI 60871-4:2014)

Parallelkondensatoren für Wechselspannungs-Starkstromanlagen mit einer Bemessungsspannung über 1 000 V - Teil 4: Eingebaute Sicherungen
(IEC 60871-4:2014)

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Foreword

The text of document 33/548/FDIS, future edition 2 of IEC 60871-4, prepared by IEC/TC 33, "Power capacitors and their applications" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60871-4:2014.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-02-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-05-01

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Annex ZA
(normative)
Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60871-1	2005	Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V -- Part 1: General	EN 60871-1	2005

CONTENTS

SHUNT CAPACITORS FOR AC POWER SYSTEMS HAVING A RATED VOLTAGE ABOVE 1 000 V –

Part 4: Internal fuses

1 Scope and object

This part of IEC 60871 applies to internal fuses which are designed to isolate faulty capacitor elements, in order to allow operation of the remaining parts of that capacitor unit and the bank in which the capacitor unit is connected. Such fuses are not a substitute for a switching device such as a circuit-breaker, or for external protection of the capacitor bank or any part thereof.

The object of this part of IEC 60871 is to formulate requirements regarding performance and testing and to provide a guide for coordination of fuse protection.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60871-1:2005, *Shunt capacitors for a.c. power systems having a rated voltage above 1000 V – Part 1: General*

3 Terms and definitions

For the purpose of this part of IEC 60871, the terms and definitions in IEC 60871-1, as well as the following, apply.

3.1
rated voltage of a capacitor element
U_{Ne}
r.m.s. value of the alternating voltage for which the capacitor element has been designed

4 Performance requirements

4.1 General

The fuse is connected in series to the element(s) which the fuse is intended to isolate if the element(s) becomes faulty. The range of currents and voltages for the fuse is therefore dependent on the capacitor design, and in some cases also on the bank in which the fuse is connected.

The requirements are valid for a bank or a capacitor switched by restrike-free circuit-breakers. If the circuit-breakers are not restrike-free, other requirements shall be agreed between manufacturer and purchaser.

The operation of an internal fuse is in general determined by one or both of the two following factors:

– the discharge energy from elements or units connected in parallel with the faulty element or unit;
– the power-frequency fault current.

The additional current and voltage resulting from the blowing of some fuses should be taken into account in the design.

4.2 Disconnecting requirements

The fuse shall enable the faulty element to be disconnected when electrical breakdown of elements occurs in a voltage range, in which $u_1 = 0{,}9 \times \sqrt{2} U_{\text{Ne}}$ is the lowest, and $u_2 = 2{,}5 \times \sqrt{2} U_{\text{Ne}}$ is the highest (instantaneous) value of the element voltage at the instant of fault.

The range u_1 to u_2 is based on the voltage that might occur across the capacitor element at the instant of electrical breakdown.

The u_2 value is of a transient nature, mostly related to switching operations, and some allowance has been made for the extra voltage increase that might occur (before activation of protection) due to earlier disconnection of parallel elements in a series group of elements (See B.1).

If the application of capacitors leads to u_1 and u_2 value, other than those indicated, for example for filter capacitors or when the protection settings limit the value of overvoltage, the lower and upper test voltage limits shall be changed according to an agreement between manufacturer and purchaser.

4.3 Withstand requirements

After operation, the fuse assembly shall withstand full element voltage, plus any unbalance voltage due to fuse action, and any short-time transient overvoltages normally experienced during the life of the capacitor.

Throughout the life of the capacitor, the fuses shall be capable of carrying continuously a current equal to or greater than the maximum permissible unit current divided by the number of parallel fused paths.

The fuses shall be capable of withstanding the inrush-currents due to the switching operations expected during the life of the capacitor.

The fuses connected to the undamaged elements shall be able to carry the discharge currents due to the breakdown of elements.

The fuses shall be able to carry the currents due to short-circuit faults on the bank external to the unit(s) occurring at a peak voltage of $2{,}5 \times U_{\text{N}}$.

5 Tests

5.1 Routine tests

5.1.1 General

The fuses shall be able to withstand all routine tests of the capacitor unit in accordance with IEC 60871-1.

5.1.2 Discharge test

Capacitors having internal fuses shall be subjected to one short-circuit discharge test, from a d.c. voltage of 1,7 U_N through a gap situated as closely as possible to the capacitor, without any additional impedance in the circuit (see note).

The capacitance shall be measured before and after the discharge test. The difference between the two measurements shall be less than an amount corresponding to one internal fuse operation.

The discharge test may be made before or after the voltage test between terminals (see IEC 60871-1:2005, Clause 9). However, if it is made after the voltage test between terminals, a capacitance measurement at rated voltage shall be made afterwards to detect fuse operation.

If, by agreement with the purchaser, capacitors are accepted with operated fuses, the voltage test between terminals (IEC 60871-1:2005, Clause 9) shall be made after the discharge test.

It is permitted that d.c. charging voltage be generated by initially energizing with an a.c. voltage of 1,7 U_N peak value and disconnecting at a current zero. The capacitor is then immediately discharged from this peak value.

Alternatively, if the capacitor is disconnected at a slightly higher voltage than 1,7 U_N, the discharge may be delayed until the discharge resistor reduces the voltage to 1,7 U_N.

5.2 Type tests

The fuses shall be able to withstand all type tests of the capacitor units in accordance with IEC 60871-1.

The unit(s) shall have passed all routine tests stated in IEC 60871-1.

A disconnecting test on fuses (see 5.3) shall be performed either on one complete capacitor unit or, at the choice of the manufacturer, on two units, one unit being tested at the lower voltage limit, and one unit at the upper voltage limit, in accordance with 5.3.1.

Due to testing, measuring and safety circumstances, it may be necessary to make some modifications to the unit(s) under test; for example those indicated in annex A. See also the different test methods given in Annex A.

Type tests are considered valid if they are performed on capacitor(s) of a design identical with that of the capacitor offered, or on a capacitor(s) of a design that does not differ from it in any way that might affect the properties to be checked by the type tests.

5.3 Disconnecting test on fuses

5.3.1 Test procedures

The disconnecting test on fuses shall be performed at the lower a.c. element voltage limit of $0{,}9 \times U_{Ne}$ and at the upper voltage limit of $2{,}5 \times U_{Ne}$ or other values according to an agreement between manufacturer and purchaser

If the test is carried out with d.c., the test voltage shall be $\sqrt{2}$ times the corresponding a.c. test voltage.

NOTE Normally the dielectric would only withstand an a.c. voltage of 2.5 U_N for a very limited period of time. Therefore a test with d.c. is in most cases to be preferred.

If the test is carried out with a.c., the triggering of the element failure with a voltage peak shall not be necessary for the test at the lower voltage limit.

Certain test methods are indicated in Annex A.

5.3.2 Capacitance measurement

After the test, the capacitance shall be measured to prove that the fuses have blown. A measuring method shall be used that is sufficiently sensitive to detect the capacitance change caused by one blown fuse.

5.3.3 Inspection of the unit

Before opening, no significant deformation of the container shall be apparent.

After opening the container, a check shall be made to ensure that:

a) no severe deformation of sound fuses is apparent;

b) no more than one additional fuse (or one-tenth of fused elements directly in parallel) has been damaged (see note 1 to Clause A.1). If method b) given in Annex A is used, note 1 to Clause A.1 shall be observed.

NOTE A small amount of blackening of the impregnant will not affect the quality of the capacitor.

It should be noted that dangerous trapped charges may be present on elements disconnected either by operated fuses or by damage to their connections. All elements should be discharged with great care.

5.3.4 Voltage test after opening the container

A voltage test shall be carried out by applying a d.c. voltage of $3{,}5 \times U_{\mathrm{Ne}}$ (U_{Ne} element voltage) for 10 s across the broken down element and the gap in its blown fuse. The element and the fuse should not be removed from the unit for this test. During the test, the gap shall be in the impregnant. No breakdown over the fuse gap or between any part of the fuse and any other part of the unit is allowed.

NOTE For units with all elements in parallel, or in all other cases if test procedure b), c), d), or e) indicated in Annex A is used, this test can be replaced by an a.c. test before the opening of the unit. The test voltage between the terminals is calculated using the capacitance ratio such that the voltage across the breakdown element and the gap in its blown fuse is $3{,}5 \times U_{\mathrm{Ne}} \big/ 2$.

Annex A
(normative)

Test procedures for the disconnecting test on internal fuses

A.1 General

One of the test procedures a), b), c), d), e) or an alternative method, shall be used.

The capacitor voltage and current shall be recorded during the test to verify that the fuse has disconnected correctly.

To verify the current-limiting behavior of the fuses when tested at the upper voltage limit, the voltage drop, excluding transient, across the blown fuse shall not exceed 30 %.

If the voltage drop exceeds 30 %, precaution shall be taken to make certain that the parallel stored energy and the power-frequency fault current available from the test system are representative of service conditions. A test shall then be made under these conditions to demonstrate satisfactory operation of the fuse.

Precautions should be taken when performing this test against the possible explosion of a capacitor unit and the explosive projection of the nail.

NOTE At the upper voltage limit, one additional fuse (or one-tenth of the fused elements directly in parallel) connected to a sound element(s) is allowed to be damaged.

A.2 Test procedures

a) Capacitor preheating

The capacitor unit is preheated in a chamber before applying the a.c. test voltage at the lower voltage limit. Preheating temperature (100 °C to 150 °C) is chosen by the manufacturer to achieve a practical short time (some minutes to some hours) to the first breakdown.

To prevent excessive internal liquid pressure due to high temperature, the unit may be equipped with a relief tube including a valve which is closed at the instant of applying the test voltage.

A lower preheating temperature may be used when applying the test voltage at the upper voltage limit, in order to avoid breakdowns before reaching the test voltage.

b) Mechanical puncture of the element

Mechanical puncture of the element is made by a nail, which is forced into the element through a pre-drilled hole in the container. The test voltage may be d.c. or a.c., the choice being left to the manufacturer.

If a.c. voltage is used, the timing of the puncture shall be made so that breakdown occurs close to the instant of peak voltage.

Puncture of only one element cannot be guaranteed. In order to limit the possibility of a flashover to the container along the nail, or through the hole caused by the nail, the punctures may be performed in the elements connected, permanently or during the test, to the container.

NOTE DC voltage is especially suitable for capacitors having all elements in parallel.

c) Electrical breakdown of the element (first method)

Some elements in the test unit are each provided with, for example, a tab inserted between the dielectric layers. Each tab is connected to a separate terminal.

The test voltage may be a.c. or d.c. the choice being left to the manufacturer.

To obtain breakdown of an element thus equipped, a surge voltage of sufficient amplitude is applied between this tab and one of the foils of the modified element.

In the case of a.c. voltage, the surge shall be triggered close to the instant of peak voltage.

d) Electrical breakdown of the element (second method)

Certain elements in the test unit are each provided with a short fusible wire connected to two extra tabs and inserted between the dielectric layers. Each tab is connected to a separate insulated terminal.

The test voltage may be d.c. or a.c., the choice being left to the manufacturer.

To obtain breakdown of an element equipped with this fusible wire, a separate capacitor charged to a sufficient voltage is discharged into the wire in order to blow it.

In the case of a.c. voltage, the discharge of the charged capacitor causing the wire to blow shall be triggered off close to the instant of the peak voltage.

e) Electrical breakdown of the element (third method)

A small part of an element (or of several elements) in a unit is removed at the time of manufacture and replaced with a weaker dielectric.

For example: 10 cm^2 to 20 cm^2 of a film-paper-film dielectric is cut out and replaced with two thin papers.

Annex B
(informative)

Guide for coordination of fuse protection

B.1 General

The fuse is connected in series with the element that the fuse is designed to isolate if the element becomes faulty. After the breakdown of an element, the fuse connected to it will blow and isolate it from the remaining part of the capacitor, which allows the unit to continue in service. The blowing of one or more fuses will cause voltage changes within the bank.

The voltage across sound unit(s) should not exceed the value given in IEC 60871-1.

Depending on the internal connection of the units, the blowing of one or more fuses may also cause a change of voltage within the unit.

The remaining elements in a series group will have an increased working voltage, and the manufacturer should, on request, give details of the voltage rise caused by blown fuses.

B.2 Protection sequence

The protection of a capacitor bank shall operate selectively.

The first step is the internal fuses of the elements.

The second step is the relay protection of the bank (e.g. overcurrent or unbalance protection).

The third step is network or plant protection.

Depending on the output of the bank, the design of the relay protection etc., all the three steps are not necessarily used in all capacitor banks.

In large banks, an alarm stage may also be used.

Unless the fuse always blows as a result of discharge energy within the voltage range given in 4.2, the manufacturer should provide the current/time characteristic and tolerance of the fuse.

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BSI Group Headquarters

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